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DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES

INVESTIGATIONAL REPORT No. 40

THE SOUTH AFRICAN PILCHARD

(Sardinops ocellata)

AND MAASBANKER

*(Trachurus trachurus)*A PRELIMINARY STUDY OF THE
SALPS AND DILIOLIDS OFF THE
WEST AND SOUTH COASTS OF
SOUTH AFRICA

BY

R. P. VAN ZYL

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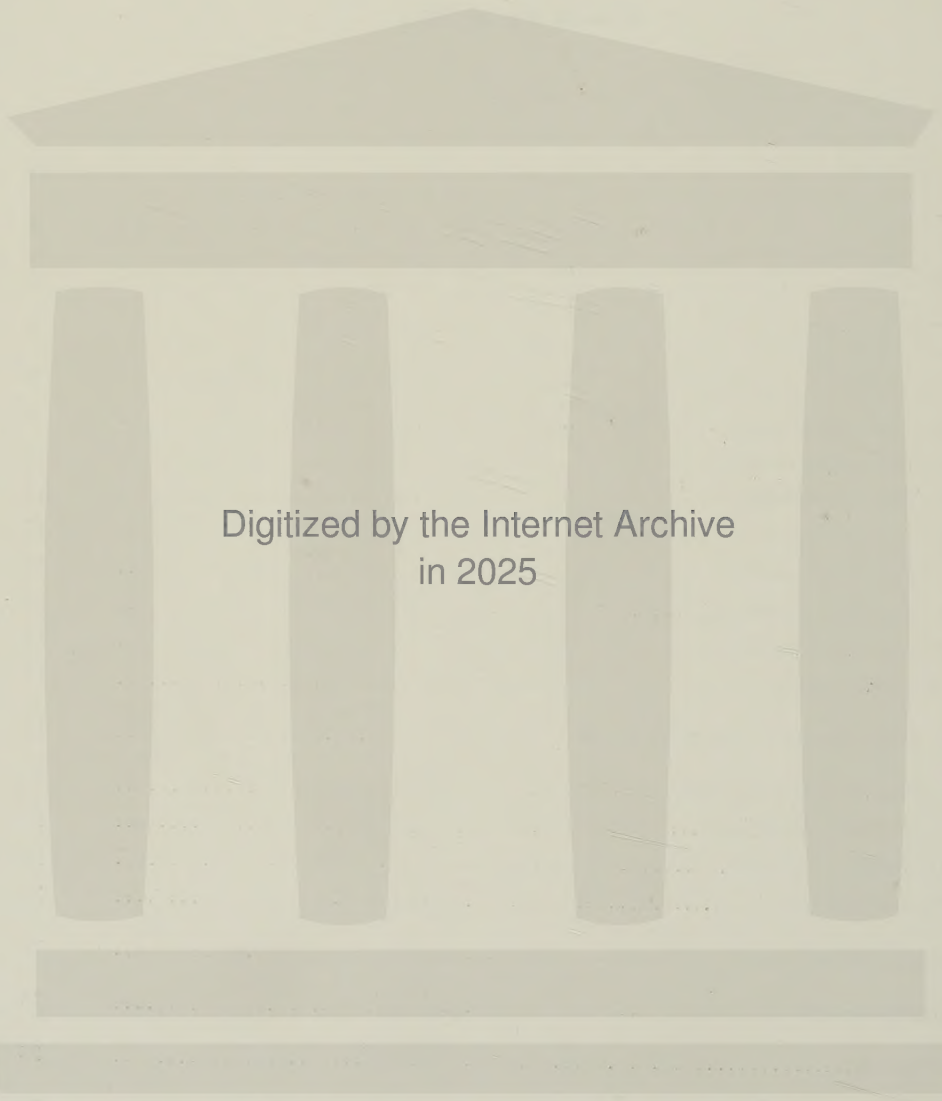
INVESTIGATIONAL REPORT No. 40

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I. SUMMARY.

This report is one of a series on the life history of the pilchard *Sardinops ocellata* (Pappé) and the maasbanker *Trachurus trachurus* (Linné). It deals with the bionomics of some of the salps and doliolids to be found mainly off the West coast of South Africa with special reference to their importance as indicators of water movements. Salps occurring off the South coast are also discussed.

Eight species of salps and three species of doliolids are recorded. One of these species of salps was found at Walvis Bay, north of the routine research area, whilst another was found to occur only off the South coast.

The following salps and doliolids were identified from the plankton catches:—

Thalia democratica in routine and South coast areas.

Thalia longicauda in routine and South coast areas.

Salpa fusiformis in routine and South coast areas.

Pegea confoederata in routine and South coast areas.

Salpa maxima off the South coast.

Ihleia magalhanica in the routine area.

Cyclosalpa virgula off the coast of South West Africa.

Cyclosalpa pinnata in the routine area.

Doliolum denticulatum in the routine and South coast areas.

Doliolum nationalis in the routine area.

Doliolum tritonis in the routine area.

The findings of this preliminary investigation into the biology of salps and doliolids are briefly as follows:—

1. The highest frequencies of most of the species of salps and doliolids investigated are found in spring and summer. *Doliolum nationalis*, however, has its highest incidence during winter.
2. A direct relationship exists between the quantitative occurrence of the salps and two species of doliolids and the mean integral temperature of the sea between 0 and 50 metres. The occurrence of *Doliolum nationalis* shows an inverse relation with the temperature of the latter layer.
3. Salps and doliolids are mainly "inedible" forms of plankton and consequently do

not form a part of the diets of pilchards and maasbankers.

4. Salps feed mainly on phytoplankton and juvenile stages of *Euphausiacea*, *Themisto* and *Copepoda*.
5. On very rare occasions were eggs of pelagic fish present in the contents of the nuclei of salps.
6. Salps and doliolids occurred very rarely at the inshore routine stations.
7. The aggregate zooids of the more common salps and gonozooids of the doliolids most frequently encountered, were much more abundant in the plankton tow-net hauls than the solitary zooids of the salps and oozoids of the doliolids.
8. When one species of salp or doliolid occurred abundantly, it was seldom found in association with other species of salps or doliolids in the plankton.
9. The presence of *Salpa fusiformis*, *Ihleia magalhanica* and *Thalia democratica* in the routine area during September to November, 1955, suggests an influx of water from the South Atlantic ocean to the routine area in these months. This influx was probably due to the occurrence of southerly and south easterly winds during this period. On the other hand, the presence of *Thalia longicauda*, *Pegea confoederata* and *Cyclosalpa pinnata* in the routine area during December, 1955, to March, 1956, would appear to show that water from the Agulhas current had spread to this area at this time of the year.

2. INTRODUCTION.

Data on salps and doliolids were collected from April, 1954, to March, 1956, at the stations of the routine research area (see Fig. 1). This constituted a two-year period and each year was divided into seasons as follows:—

March, April, May representing *autumn*.

June, July, August representing *winter*.

September, October, November representing *spring*.

December, January, February representing *summer*.

During autumn, 1954, data were available only for April and May.

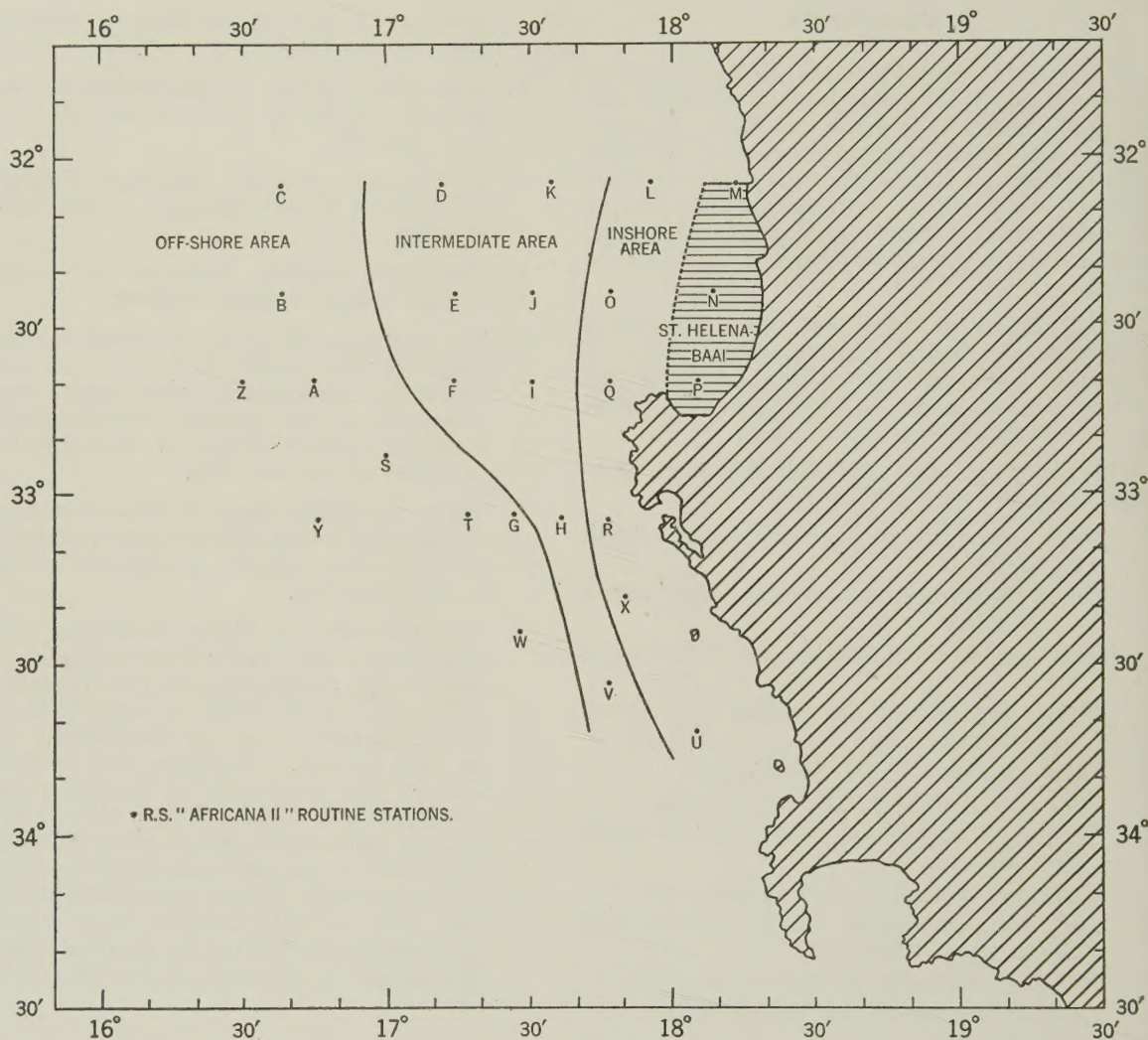


FIG. 1.

ROUTINE RESEARCH AREA.

Initially the routine research stations off the West coast were numbered from A to X, but station S was discontinued from 1955 onwards and two additional off-shore stations, namely Y and Z, were added (see Fig. 1). Averages were calculated for the respective number of stations in the period under review.

During 1954 R.S. *Africana II* worked stations to the south and east of Cape Point as far east as Cape Barracouta with the object of locating spawning areas of pilchard and associated pelagic species. During these cruises surface and oblique

hauls were also made at stations, and these plankton catches yielded species not encountered off the West coast. In addition one species of the cyclosalps was caught at Walvis Bay during a special cruise in September, 1955.

3. METHOD.

Once a month R.S. *Africana II* completed a network of routine stations covering approximately 4,000 square miles in and adjacent to the St. Helena Bay area. At these stations biological,

hydrological and meteorological observations were made.

Biological activity included sampling of the plankton by means of horizontal and oblique tow-nets which were of the standard types used by R.R.S. *Discovery*. (Kemp, Hardy and Macintosh, 1929.)

Hydrological observations included the taking of sea-water samples at various depths for salinity determinations. The temperature of the sea water at these depths was also recorded.

The meteorological data included four-hourly weather observations.

The horizontal or N100H-net was towed just below the surface of the water for ten minutes. At the same time an oblique or N100B-net was towed at an angle of 60° to the vertical from 150 metres to the surface or from 10 metres off the bottom to the surface of the water. These oblique hauls usually took from 8 to 15 minutes, depending upon the depth from which the net was hauled.

If salps were very abundant in the hauls and the nets were filled almost to capacity, only an aliquot sample was taken and the rest of the catch was discarded after the volume of salps caught had been assessed with the aid of a measuring cylinder.

If in an abundant haul more than one species of salp were present, their numbers were calculated in proportion to the volume of the catch. The numbers of solitary and aggregate individuals of one species were similarly calculated relative to the volume of the catch. It was the exception to find more than one species of salp or doliolid in an abundant haul.

The plankton samples collected were preserved in 10 per cent neutral formalin and were brought to the laboratory at headquarters for detailed analysis. The salps and doliolids were separated for identification and were placed in specimen tubes together with a label stating the date, station, gear used, and the depth from which the catch was made.

The numbers of individuals present in a sample were estimated and the quantities were expressed as follows:—

- very abundant, representing 3,000 or more individuals;
- abundant, representing 1,000 individuals;
- less abundant, representing 300 individuals;
- common, representing 100 individuals;
- plus, representing 30 individuals;

few, representing 10 individuals; and
rare, representing 1–3 individuals.

These numbers are approximate and were used throughout as standards when estimating the numbers of salps and doliolids in a given sample.

The various species of salps and doliolids were identified by means of characteristic features. Such features enabled quick and easy recognition of the individuals of the more common species of salps and doliolids under a dissecting microscope. The lesser known species of salps required careful and detailed analysis for identification.

Some of the larger salps such as *Salpa maxima* and *Pegea confoederata* could readily be distinguished by the naked eye, but the gonozooids of doliolids and smaller salps could only be recognised under higher magnification.

Identification of salps was done morphologically by means of—

1. The number, thickness and arrangement of the body muscle bands.
2. The shape and thickness of the test.
3. The structure of the neural ganglion.

The morphological characteristics which were used to identify doliolids were—

1. The structure of the alimentary tract.
2. The number, width and distribution of the body muscle bands.
3. Location of the branchial septum in relation to the body muscle bands.
4. Positioning of the endostyl in relation to the body muscle bands.

Solitary individuals of the salps could also be distinguished from the aggregate individuals of the same species by an additional chain or stolon.

The oozoid stages of doliolids could readily be distinguished from the gonozooids; the oozoids, being larger and having more robust muscle bands, some of which were united into a continuous sheet, could easily be identified.

The numbers of oozoids and gonozooids of doliolids were combined for the purpose of this report. The oozoids have always been found in considerably smaller numbers compared with those of the gonozooids. Two types of oozoids have been recorded, namely, those of *Doliolum tritonis* and *D. denticulatum*. The oozoids of *Doliolum nationalis* were absent at the routine stations. This might possibly be

due to the similarity of the oozoid stages of the latter species and those of *D. denticulatum*, both having the body muscle bands united thus forming a continuous sheet.

4. NOTES ON SPECIES OF SALPS.

(a) *Thalia democratica*.

(i) Areas of distribution.

This is the commonest species of the salps found in the area investigated; it occurred at all seasons in the routine area which can be divided into four main sections, viz., off-shore, intermediate, inshore and St. Helena Bay areas (see Fig. 1).

In autumn small numbers only of aggregate and solitary individuals of *T. democratica* were found in the off-shore area. A similar area was occupied by this salp during winter although larger concentrations were found.

During spring the distribution of *T. democratica* covered the major part of the routine area, with the exception of the St Helena Bay area, where no salps were found.

The same condition was found during summer; the only difference being that smaller concentrations were found in the intermediate and inshore sections of the routine area.

There was no marked difference in the distribution of *T. democratica* during the periods April, 1954, to February, 1955, and March, 1955 to February, 1956. The average abundances per station for each period remained fairly constant. Average concentrations varied from "+" to "abundant" in the off-shore areas; from "few and rare" to "abundant" in the intermediate areas and from "few and rare" to "common" in the inshore areas (see Plates I and II).

(ii) Seasonal occurrences from April, 1954, to February, 1956.

Autumn, 1954 (data from April and May only).

During autumn, 1954, small numbers only of aggregate individuals of *T. democratica* were present. The mean integral temperature of the 0-50 metres layer was highest at the off-shore routine stations. A few individuals only of the aggregate zooids were found at stations A and S, where the mean integral temperatures of this layer were 18.92°C and 17.47°C, respectively.

Winter, 1954.

The numbers of aggregate individuals increased and the occurrence spread nearer the coast than in autumn. This might indicate a landward approach of oceanic water. The largest catches were made in the oblique tow-net hauls at stations A, G, H, S and T. The mean integral temperatures of the 0-50 metres layer at these stations were 14.45°, 14.94°, 14.77°, 15.03° and 14.56°C, respectively.

Spring, 1954.

T. democratica was found throughout the routine area, except at stations M, N, P and Q situated close inshore between Lambert's Bay and Cape Columbine. Largest concentrations were still found at the off-shore stations, the numbers decreasing landwards.

At the off-shore stations the catches consisted mainly of aggregate zooids and outnumbered solitary zooids by a ratio of 4.5:1 in the horizontal hauls and 5.1:1 in the oblique hauls. The total estimated number of individuals caught during this season was 24,062; the highest figure for this year. The maximum and minimum mean integral temperatures of the 0-50 metres layer at the off-shore routine stations where these catches were made, were 16.49°C and 12.65°C, respectively. Both these extremes were recorded during October, 1954.

Summer, 1954-55.

In summer the numbers of *T. democratica* present in the routine area were less than in winter. This was noticeable for both the solitary and aggregate zooids found in the oblique and horizontal tow-nets. Largest numbers, however, were still present in the horizontal tow-net hauls in which the aggregate zooids predominated. A total of approximately 2,500 individuals was caught during this season, mainly at stations B, D, G, T and W in December, 1954, and station W in February, 1955. The highest and lowest mean integral temperature values for the 0-50 metres layer were 17.06°C and 13.97°C, respectively; these values were found at stations T, (maximum) and D (minimum) during December 1954.

Larger numbers of *T. democratica* were caught during the period March, 1955, to February, 1956, than in the comparable period in 1954/1955. The seasonal catches made were as follows:—

Autumn, 1955.

High concentrations of aggregate zooids of *T. democratica* were found at the off-shore routine

stations. These catches were made at stations Z, A, D and T in April and station Y in May. The highest mean integral temperature of the 0-50 metres layer for these stations was 17.38°C, recorded at station A in April; the lowest was 15.35°C recorded at station Y in May.

Winter, 1955.

During the winter months, *T. democratica* was still found at the off-shore stations in moderate numbers, equally divided in the horizontal and oblique tow-net catches. Largest concentrations were encountered at station U in July and stations A, B, C and Y in August, 1955. The respective highest and lowest mean integral temperatures of the 0-50 metres layer were 15.30°C recorded at station Y in August and 13.03°C recorded at station U in July.

Spring, 1955.

Large specimens of *T. democratica* with violet-coloured nuclei occurred *abundantly* at the off-shore stations, but the numbers decreased to *few and rare* at the inshore stations. The aggregate zooids predominated over the solitary zooids by a ratio of 12:1 in the oblique hauls and 6.5:1 in the horizontal hauls. Maximum and minimum mean integral temperature values of the 0-50 metres layer of 16.23°C and 13.40°C were recorded at stations T in November and W in October, respectively.

Summer, 1955-56.

The numbers of *T. democratica* decreased considerably in both horizontal and oblique hauls. Highest concentrations were still encountered off shore where aggregate zooids predominated over solitary zooids by ratios of 7.6:1 and 5.1:1 in the horizontal and oblique hauls, respectively. The highest and lowest mean integral temperature of the 0-50 metres layer were 18.99°C and 11.76°C recorded at stations W and O respectively during January, 1956; the largest catches were made in the middle of this temperature range.

The approximate numbers of aggregate (Agg.) and solitary (Sol.) individuals caught (in the horizontal and oblique tow-net hauls) during the two years are given in Table 1.

(iii) Discussion.

In general, larger catches of *T. democratica* were made in the horizontal than in the oblique hauls. This salp was found in greatest abundance at routine stations where relatively high mean integral temperature values for the 0-50 metres layer were obtained; this was usually the case at the off-shore stations (see Fig. 2).

TABLE 1.

Season.	1954-55.						1955-56.					
	N100H.			N100B.			N100H.			N100B.		
	Agg.	Sol.	Ratio, Agg./Sol.	Agg.	Sol.	Ratio, Agg./Sol.	Agg.	Sol.	Ratio, Agg./Sol.	Agg.	Sol.	Ratio, Agg./Sol.
Autumn	—	3*	—	3*	3*	1.0-1	76	—	—	15	—	—
Winter..	36	32	1.1-1	378	62	6.1-1	530	173	3.1-1	533	113	4.7-1
Spring..	14,600	3,232	4.5-1	5,201	1,029	5.1-1	13,063	1,995	6.5-1	11,555	959	12.0-1
Summer	2,690	359	7.5-1	685	216	3.2-1	1,412	185	7.6-1	1,072	209	5.1-1

* Autumn 1954 averages of two months only.

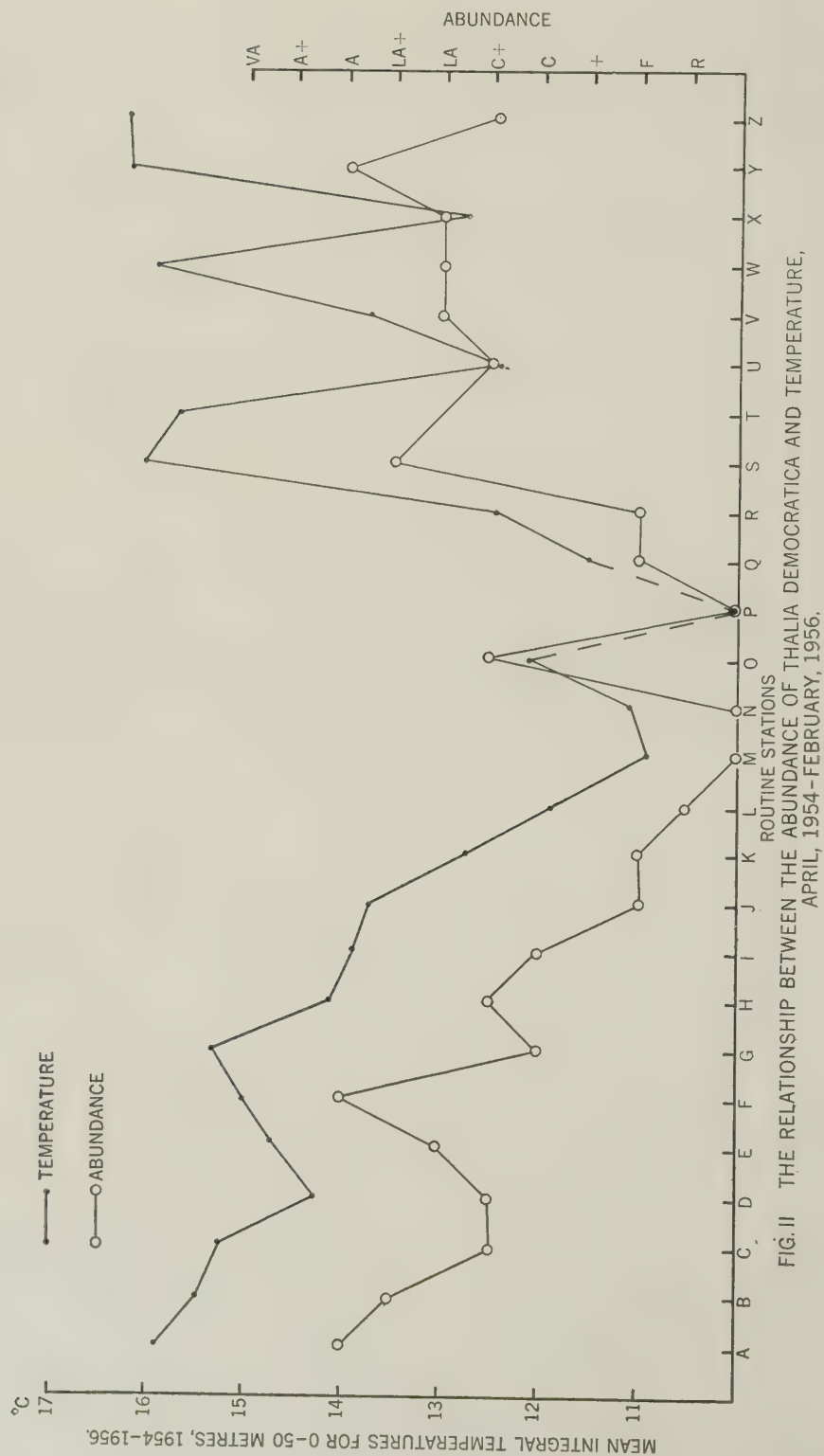


FIG. II THE RELATIONSHIP BETWEEN THE ABUNDANCE OF *Thalia democratica* AND TEMPERATURE, APRIL, 1954-FEBRUARY, 1956.

(a) Seasonal variation.

Very small numbers of *T. democratica* were found during the autumn of 1954 and of 1955. In winter the numbers increased slightly in both the horizontal and oblique hauls. During spring, however, a sudden increase in numbers occurred; thus nearly 18,000 individuals were recorded in the surface hauls and approximately 6,000 individuals in the oblique hauls during the spring of 1954, whilst in the same season of 1955, approximately 15,000 individuals were recorded in the surface hauls and nearly 12,000 individuals in the oblique tow-net hauls (see Table 1). The numbers declined during both summer seasons in 1954/55 and 1955/56.

Year 1954-55.

In surface hauls the ratio of aggregate to solitary zooids of *T. democratica* was highest during summer [7.5 (agg.) to 1 (sol.)] and lowest during winter [1.1 (agg.) to 1 (sol.)].

In oblique hauls the highest ratio of aggregate to solitary zooids was found during winter, viz. [6.1 (agg.) to 1 (sol.)] and the lowest during summer [3.2 (agg.) to 1 (sol.)].

Year 1955-56.

In surface hauls the maximum value of the ratio of aggregate to solitary zooids was again

found during summer, viz. [7.6 (agg.) to 1 (sol.)], whilst the lowest occurred during winter [3.1 (agg.) to 1 (sol.)].

In oblique hauls the ratios of aggregate to solitary zooids showed a marked deviation during the latter part of 1955 when the ratios were the highest during spring, viz. [12.0 (agg.) to 1 (sol.)] and decreased in summer [5.1 (agg.) to 1 (sol.)] to a value still greater than that of the winter season (see Table 1).

This deviation can only be explained as being due to the changing hydrological conditions such as can be caused by an influx of Agulhas current water from the South coast to the routine area during the latter part of the year. This warmer, sub-surface water probably promoted the extensive increase in numbers of *T. democratica* in sub-surface water.

(b) Percentage composition of aggregate and solitary zooids.

The combined percentages of composition of aggregate and solitary zooids in the surface and oblique tow-net hauls during the period April, 1954, to February, 1956, are given in Table 2.

TABLE 2.

Season.	1954-55.		1955-56.	
	Percentage Composition.		Percentage Composition.	
	Agg.	Sol.	Agg.	Sol.
	% —*	% —*	% —*	% —*
Autumn.....	81.5	18.5	78.8	21.2
Winter.....	82.3	17.7	89.4	10.6
Spring.....	85.4	14.6	86.2	13.8
Summer.....				
Average.....	83.07	16.93	84.80	15.20

* Data for autumn seasons omitted due to infrequent occurrences of *T. democratica*.

The composition of the populations of *T. democratica* fluctuated to a slight extent in the combined catches of the surface and oblique tow-net hauls during the observation period.

The aggregate zooids had an overall composition of 83.07 per cent in the period 1954/55 and 84.80 per cent in 1955/56, whilst the solitary zooids had values of 16.93 per cent and 15.20 per cent, respectively, during the corresponding periods.

(b) *Thalia longicauda*.

This species was absent during the period April, 1954, to February, 1955, in the routine area, but was found on three occasions during the

period March, 1955, to February, 1956. On all three occasions large numbers were found in both horizontal and oblique hauls. The approximate numbers of individuals caught are shown in Table 3.

TABLE 3.

Station.	Date.	N100H		N100B		Temperature °C.	
		Agg.	Sol.	Agg.	Sol.	0-50 Metres.	0 Metres.
A.....	22/5/55	1,000	100	300	30	15.07	17.03
F.....	18/2/56	300	3,000	100	3,000	15.13	17.51
I.....	18/2/56	30	300	30	100	14.41	16.71

This species is not limited to the West coast for it was found on two occasions in large numbers at two stations off the South coast in March, 1955

(see Plate III.) The surface temperatures at these two stations (2852, 2854) were 20.7°C and 21.0°C, respectively. The catches of *T. longicauda* made at these two stations are given in Table 4.

TABLE 4.

Station.	Date.	N100H.		N100B.	
		Agg.	Sol.	Agg.	Sol.
2852.....	3/3/55	300	30	1,000	300
2854.....	3/3/55	100	30	1,000	100

It is possible that *T. longicauda* is an Indian Ocean species and its absence in the routine area in winter may be connected with the fact that during this season the flow of water in the Agulhas current is less than in other seasons, and that none rounds Cape Point at this time of the year. If the species is of Indian Ocean origin it would not appear in tow-net hauls in the routine area in winter.

During 1956, no search cruises were made off the South coast, with the result that no more data were available from there, but during February, 1956, large numbers of *T. longicauda* were again encountered at two of the routine stations, viz. stations F and I off the West coast. The surface temperatures were 17.51°C and 16.71°C, respectively.

During summer and early autumn strong southerly and south-easterly winds prevail which

could be the driving forces causing an influx of warmer surface water from the South to the West coasts and hence account for the occurrence of *T. longicauda* in the routine area during these seasons.

Recent unpublished data concerning the origin of the warm and saline water off the western side of the Cape Peninsula appears to show that in summer, water from the Agulhas current does round the Peninsula and enter the South Atlantic ocean. This flow might account for the presence of *T. longicauda* in the routine area in May, 1955, and February, 1956.

(c) *Ihleia magalhanica*.

This species was absent during the period April, 1954, to February, 1955, but in November, 1955, it was found on three occasions.

Sewell (1926) states that its distribution is limited to the deeper layers of sea-water and Thompson (1948) reports that the occurrence of *I. magalhanica* is limited almost entirely to the water layer between a depth of 50 metres and the surface. The specimens which were obtained

from the routine area off the West coast were all found in the oblique plankton tow-net hauls which cover a depth of 150 metres to the surface. Only 8 solitary individuals of *I. magalhanica* were found, these being at routine stations F, G and Z. Table 5 gives details of these catches.

TABLE 5.

Date.	Station.	N100H		N100B		Temperature °C.
		Agg.	Sol.	Agg.	Sol.	0-50 Metres.
26/11/55.....	F	—	—	—	3	15.59
25/11/55.....	G	—	—	—	3	15.97
26/11/55.....	Z	—	—	—	2	15.72

Thompson (1948) points out that *I. magalhanica* is a salp which has a low tolerance for warm water conditions, whilst Apstein (1906 b) reported the occurrence of this salp South of the Cape of Good Hope.

The presence of this salp in the routine area could possibly show the presence of sub-surface water which originated from the Southern Atlantic Ocean.

(d) *Salpa fusiformis*.

The occurrence of this species in the routine area during the period April, 1954, to February, 1955, was limited to one appearance when approximately 10 aggregate individuals were caught in the oblique tow-net at station D in August of that year.

During March, 1955, to February, 1956, larger numbers were caught in the oblique hauls at the off-shore stations. These catches were made in August, September and December at the stations listed in Table 6.

TABLE 6.

Date.	Station.	N100H.		N100B.		Temperature, °C.
		Agg.	Sol.	Agg.	Sol.	0-50 Metres.
18/8/54.....	D	—	—	10	—	13.96
24/8/54.....	Y	—	—	—	3	15.30
25/8/55.....	Z	3	—	3	—	15.13
24/9/55.....	A	—	—	100	—	15.13
25/9/55.....	B	—	—	3	—	15.23
25/9/55.....	E	—	—	3	3	14.98
24/9/55.....	F	—	—	30	—	14.95
24/9/55.....	I	—	—	3	—	14.70
23/9/55.....	Y	3	—	100	100	15.16
24/9/55.....	Z	3	—	3	—	15.27
11/12/55.....	G	—	—	3	—	15.73
11/12/55.....	T	—	—	30	—	16.87
TOTAL.....		9	—	288	106	Average: 15.20

Thus a total of 297 aggregate and 106 solitary zooids of *S. fusiformis* were caught during the two-year period when the average value of the temperature of the sea-water between 0 and 50 metres was 15.20°C.

The solitary zooids of this salp were absent in surface hauls but were found at intervals in the oblique hauls. It seems probable that the solitary zooids of *S. fusiformis* inhabit the deeper waters

and that the aggregate zooids are found in surface and sub-surface layers.

(e) *Pegea confoederata*.

This species was absent in the routine area during the period April, 1954, to February, 1955,

but occurred at four stations during January in the following year 1955/56. Only aggregate zooids were found at the routine stations (see Plate III.)

Table 7 shows the numbers of aggregate zooids of *P. confoederata* caught.

TABLE 7.

Date.	Station.	N100H.		N100B.		Temperature, °C.
		Agg.	Sol.	Agg.	Sol.	0-50 Metres.
19/1/56.....	W	15	—	5	—	18.99
20/1/56.....	G	—	—	3	—	17.76
20/1/56.....	Y	4	—	3	—	18.05
21/1/56.....	Z	30	—	10	—	18.44
				Average.....		18.31

The distribution of this salp was restricted to the intermediate and off-shore routine stations. Although it was found only in small numbers, it can be deduced that *P. confoederata* inhabits relatively warm water. Metcalf (1918) gives a surface temperature range of 26.6°C to 30°C.

P. confoederata was found sporadically in small numbers off the South coast during special cruises of R.S. *Africana II*. The surface temperature of the sea-water at the stations where it was found was relatively high (20.5°C at station 2857—see Plate III).

Both *P. confoederata* and *T. longicauda* (which latter has already been noted as occurring off the

South coast) were found off the West coast during summer 1955/56. It seems that *P. confoederata* may be used as an indicator species for the presence in the routine area off the West coast of more temperate waters such as are found off the South and East coasts.

(f) *Cyclosalpa pinnata*.

This salp occurred at two stations in the routine area during 1955/56, when a few aggregate individuals were caught during January, 1956, at stations J and Y (see Plate III).

The numbers caught are given in Table 8.

TABLE 8.

Date.	Station.	N100H.		N100B.		Surface Temperature, °C.
		Agg.	Sol.	Agg.	Sol.	
20/1/56.....	Y	—	—	7	—	19.06
22/1/56.....	J	2	—	—	—	15.57
				Average.....		17.32

No solitary zooids were found at either station.

Thompson (1948) reports this species as being native to temperate waters. This is in agreement with its presence at station Y, where the surface

temperature was relatively high, but at station J the surface temperature was somewhat lower showing *C. pinnata* to be also tolerant of cooler water.

The occurrence of this salp coincided with the presence in the routine area of the salps which are normally found in temperate waters. It is probable that these species came from the area off the South coast, but were introduced into the routine area by water from the Agulhas current.

(g) *Cyclosalpa virgula*.

This species did not occur in the routine area during the period under review, but a few specimens were found during a search cruise of R.S. *Africana II* for pilchard spawning areas off Walvis Bay during September, 1955.

The details and numbers of individuals caught are shown in Table 9.

TABLE 9.

Date.	Station.	N100H.		N100B.		Surface Temperature, °C.
		Agg.	Sol.	Agg.	Sol.	
5/9/55.....	2932	3	1	—	—	11·96
5/9/55.....	2935	—	—	11	2	12·20
5/9/55.....	2936	35	4	33	—	11·92
5/9/55.....	2937	25	—	26	—	12·10
Average.....						12·05

A total of 70 aggregate and 2 solitary individuals were caught in the oblique haul and 63 aggregate and 5 solitary zooids in the surface tow-nets in water having an average surface temperature of 12·05°C. *C. virgula* appears to be of significance as a typical species of the Benguela current.

It is of interest to note that pilchard eggs occurred in large numbers at all four stations where this salp was caught, but on examining the contents of the nuclei of these salps no evidence was found of pilchard eggs being eaten. The main food item

was phytoplankton, with traces of zooplankton present.

(h) *Salpa maxima*.

This salp is the largest of all the salps found off the South and West coasts of Southern Africa. The average length of the 3 individuals caught was 12·5 cm., the largest being 16·5 cm. Only 2 solitary zooids and 1 aggregate zooid of *S. maxima* were found at 2 stations during search cruises of R.S. *Africana II* off the South coast (see Plate III). The numbers caught are given in Table 10.

TABLE 10.

Date.	Station.	N100H.		N100B.		Surface Temperature, °C.
		Agg.	Sol.	Agg.	Sol.	
2/6/54.....	2583	—	1	—	—	18·76
10/9/54.....	2664	—	1	1	—	15·75
Average.....						17·26

S. maxima occurred in conjunction with large numbers of *T. longicauda* in the surface haul at station 2583. Its absence in the routine area

during the period April, 1954, to February, 1956, can only be ascribed to the sparse distribution of this species in temperate waters.

5. FEEDING.

At intervals analyses were made of the "nucleus contents" of salps found off the South and West coasts.

Such analyses revealed that salps fed mainly on phytoplankton in inshore areas and zooplankton in off-shore areas.

The nuclei of doliolids are comparatively small; for this reason phytoplankton was present only in minute quantities and zooplankton totally absent.

It appears from comparisons made with phytoplankton catches that salps are in general filter feeders as was clearly demonstrated at station 2935 in September, 1955, off Walvis Bay.

Considerable numbers of *C. virgula* were present in the oblique haul from 50 metres to the surface at this station. An N50 vertical tow-net was also hauled from the same depth.

Comparison of the relative amounts of certain genera of phytoplankton caught in the N50V net with the relative amounts of such genera found in the nuclei of *C. virgula* taken at station 2935 in an oblique haul of a N100 net through the same vertical distance, is made in Table 11.

TABLE 11.

Phytoplankton genera.	N50V Catch.	Nucleus Contents.
	Arbitrary units.	Arbitrary units.
<i>Thalassiosira</i>	75.3	94.6
<i>Asterionella</i>	8.1	—
<i>Chaetoceros</i>	7.0	0.6
<i>Nitzschia</i>	4.3	1.2
<i>Thalassionema</i>	2.7	1.2
<i>Peridinium</i>	1.6	0.6
<i>Corethron</i>	0.5	0.6
<i>Biddulphia</i>	0.5	—
<i>Pseudoeunotia</i>	—	0.6
<i>Coscinodiscus</i>	—	0.6
TOTAL.....	100	100

There is a marked coincidence between the phytoplankton genera present in the N50 vertical net catch and in the contents of the nuclei of the salps. A cause for the differences in the arbitrary unit values of the various genera in the N50V catch and the nucleus contents of the salps, is probably the fact that the feeding area of the salps was restricted to a certain depth; whilst

the vertical net made a phytoplankton catch from 50 metres to the surface.

Large numbers of pilchard eggs were found in the surface and oblique hauls at station 2932 in September. These eggs, being pelagic, occupy the same surface layer of sea-water as *C. virgula*, which was also found in the surface haul. On examining the nucleus contents of specimens of the salp obtained at that station no traces of pilchard eggs were found.

Larger salps, e.g. *S. maxima* found off the South coast had traces of unidentified fish eggs together with phytoplankton in the contents of the nucleus, but it is doubtful whether salps having a length of $\pm 1-1.5$ cm., e.g. *T. democratica*, can feed on pelagic fish eggs. This is the average size of the zooids of *T. democratica*, which form the major part of the salp population on the West coast.

At off-shore stations the diet of salps consisted mainly of early developed stages of crustaceans such as *Amphipoda*, *Copepoda* and *Euphausiacea*.

Phytoplankton was present in small quantities.

6. NOTES ON SPECIES OF DOLIOLIDS.

(a) *Doliolum denticulatum*.

(i) Areas of distribution.

In autumn fairly large numbers of *D. denticulatum* were found in the off-shore routine area, whilst small numbers only of this doliolid were present in isolated zones in the off-shore and intermediate areas during winter.

In spring large numbers were found in the off-shore and intermediate routine areas, but numbers decreased rapidly in the inshore area and finally the species was absent in St. Helena Bay.

The summer area of distribution was identical with that of the previous season, but higher concentrations were present in summer in the routine area.

(ii) Seasonal occurrences from April, 1954, to February, 1956.

D. denticulatum was found throughout the two years at routine stations in the off-shore, intermediate and inshore areas.

The approximate numbers caught in the horizontal and oblique nets during the respective seasons of the two years are listed in Table 12.

TABLE 12.

Seasons.	1954-55.		1955-56.	
	N100H.	N100B.	N100H.	N100B.
Autumn.....	120*	280*	220	310
Winter.....	15	50	40	130
Spring.....	90	180	360	830
Summer.....	720	420	1,200	2,890

* Data for two months only, viz. April and May.

Autumn, 1954.

During this season approximately 400 individuals were caught of which 120 occurred in the horizontal and 280 in the oblique hauls, mainly at stations A, B and G during April and May. The average value of the temperature of the 0-50 metres layer of sea-water at these stations was 17.53°C.

Winter, 1954.

Small numbers only were caught at isolated stations. These stations were G, H, S, T and W. The average mean integral temperature of the 0-50 metres layer of these stations was 15.80°C.

Spring, 1954.

Small numbers of *D. denticulatum* were distributed over the off-shore and intermediate sections of the routine area, the largest concentrations being found during October and November at stations D, G, I, K and S; the average mean integral temperature of the 0-50 metres layer of these stations was 14.52°C.

Summer, 1954/55.

A total of approximately 1,140 individuals was caught during this season at stations C, B, D, E, F, G, R and X in December and station W in January, 1955. The average temperature of the 0-50 metres water layer for these stations was 15.17°C.

Autumn, 1955.

Very few individuals of *D. denticulatum* were found at the routine stations. Temperatures were generally low except at some of the off-shore routine stations, e.g. B and Y, where approximately 300 individuals were caught. The average value of the mean integral temperature of the 0-50 metres layer of the two stations was 16.85°C.

Winter, 1955.

Small numbers were caught at stations I, J, R, V and Z during this season. A total of approximately 170 individuals was taken of which 40 were in the horizontal and 130 in the oblique hauls in sea-water having an average mean integral temperature of 14.11°C for the 0-50 metres layer.

Spring, 1955.

Approximately 1,190 individuals of *D. denticulatum* were caught of which 360 individuals were taken in the surface hauls and 830 in the oblique hauls. The main catches were made at stations A, D, E, H, R, T, V, X, Y and Z. The average temperature of the 0-50 metres layer for these stations was 14.78°C.

Summer, 1955/56.

Large numbers of *D. denticulatum* were taken. In all 4,090 individuals were caught; 1,200 in the surface and 2,890 in the oblique hauls. The largest numbers were taken at stations A, B, F, G, T, U, W, Y and Z. The average mean integral temperature of the 0-50 metres layer for these stations was 16.99°C.

The distribution of *D. denticulatum* was limited to stations in the off-shore, intermediate, and inshore areas in the routine research area. It was not found close inshore at stations M, N and P in St. Helena Bay (see Plate IV).

D. denticulatum was abundant throughout the seasons of the two years at off-shore routine stations. This frequency of occurrence shows a close agreement with the temperature of the 0-50 metres water layer at the stations where *D. denticulatum* was found (see Fig. 4); largest numbers occurred in the oblique hauls (see Fig.3).

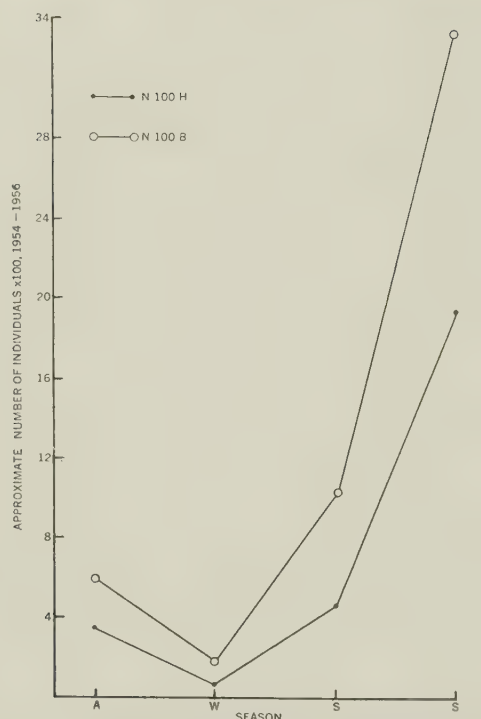


FIG. III. SEASONAL VARIATION OF DOLIOLUM DENTICULATUM
APRIL, 1954 - FEBRUARY, 1956.

(b) *Doliolum nationalis*.

This species was found on many occasions in association with *D. denticulatum*.

(i) Areas of distribution.

Small numbers were found in the off-shore area during autumn. In winter, larger numbers occurred at stations in the off-shore, intermediate and inshore areas, whereas in spring the numbers declined, but were still distributed in the same areas as in the previous season. A few individuals were found at isolated stations during the summer season of the year 1954/55, but it was absent during this season in 1955/56.

(ii) Seasonal occurrences.

The numbers of *D. nationalis* caught in the horizontal and oblique tow-nets from April, 1954, to February, 1956, are shown in Table 13.

TABLE 13.

Seasons.	1954-55.		1955-56.	
	N100H.	N100B.	N100H.	N100B.
Autumn.....	50*	20*	—	300
Winter.....	220	160	110	460
Spring.....	15	30	360	80
Summer.....	3	3	—	—

* Data for two months only, viz. April and May.

The catches made during the respective seasons of the two years were as follows:—

Autumn, 1954.

A few individuals of this species were taken at stations A and C, where the average mean integral temperature of the 0-50 metres layer was 16.27°C.

Winter, 1954.

Larger numbers were taken than in the previous season. The catches were made at nearly all

routine stations excepting those close inshore in St. Helena Bay. The average temperature of the 0-50 metres layer for stations where *D. nationalis* was found was 14.41°C.

Spring, 1954.

The main catches were made at stations in the intermediate section of the routine area. The mean temperature of the 0-50 metres layer for the 15 stations where *D. nationalis* was found was 14.03°C.

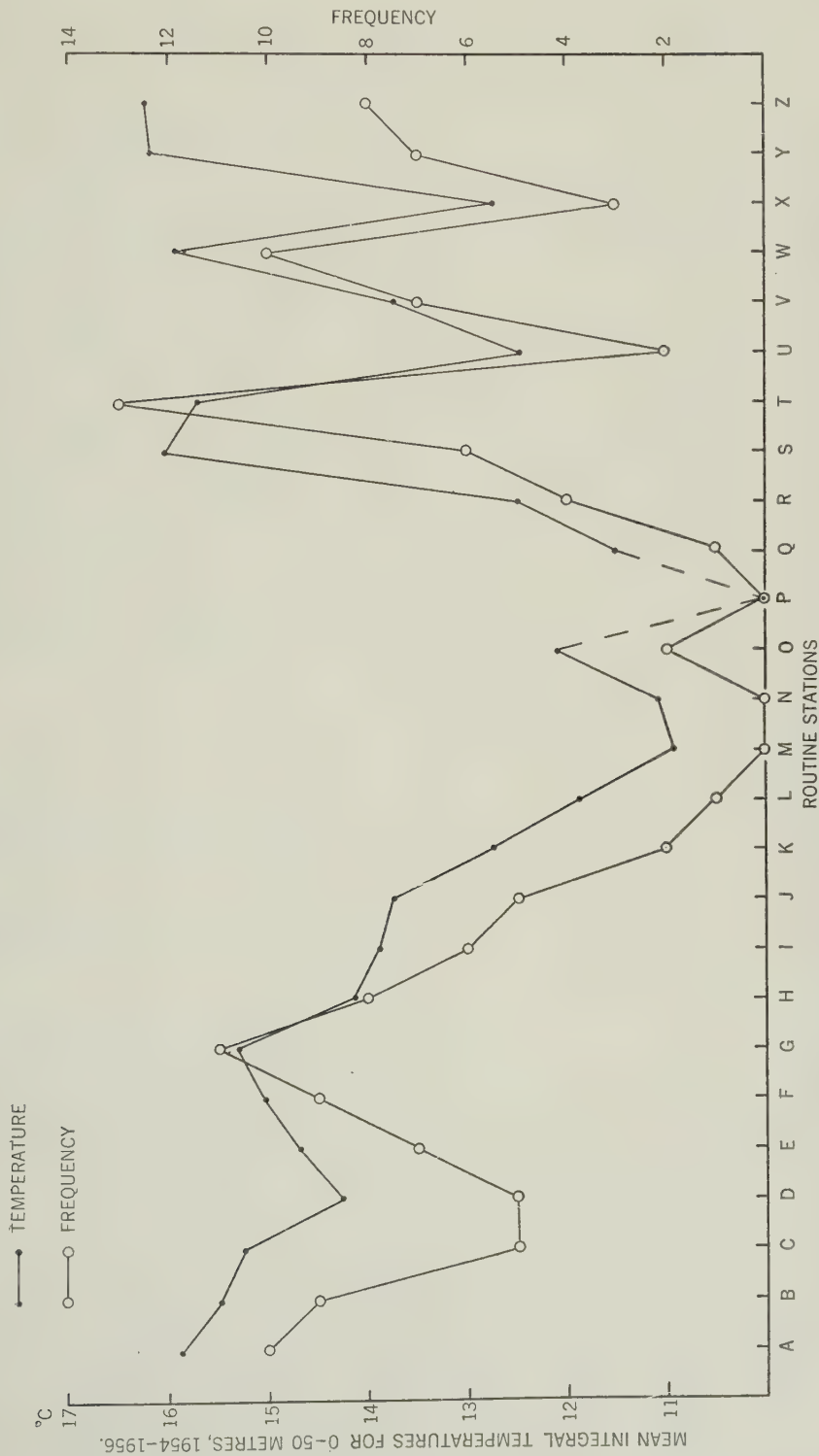


FIG. IV RELATIONSHIP BETWEEN THE FREQUENCY OF OCCURRENCE OF DOLIOLUM DENTICULATUM AND TEMPERATURE, APRIL, 1954 - FEBRUARY, 1956.

Summer, 1954/55.

Only small numbers were found at isolated stations.

Autumn, 1955.

During this season *D. nationalis* occurred at one off-shore station only, where 300 individuals were present in the oblique haul at station A. The temperature of the 0-50 metres layer was 15.07°C.

Winter, 1955.

Five hundred and seventy individuals were caught in this season, the largest catches being made at the southerly routine stations U, V and X; small numbers were found at most stations in the routine area, except those stations situated close inshore where none was found. The average mean integral temperature of the 0-50 metres water layer for the stations where *D. nationalis* occurred was 13.97°C.

Spring, 1955.

Most of the individuals caught during this season were taken in the surface hauls at off-shore stations. The average mean integral temperature of the 0-50 metres water layer where the species was found was 14.79°C.

Summer, 1955/56.

The species was absent in the routine area during this season.

The seasonal variation of *D. nationalis* is shown in Fig. 5, which represents the total number of individuals caught at routine stations during the period April, 1954, to February, 1956, in the surface and oblique hauls. The largest numbers of individuals were found in the oblique nets in winter, but a rapid decline in catches with these nets occurred in spring, by which season the surface fishing nets were catching more specimens of *D. nationalis* than the oblique nets.

Figure 6 shows the frequency of occurrence of *D. nationalis* in relation to the average mean integral temperature of the 0-50 metres layer of water at the routine stations where this species was found. This is an inversely proportional relationship and is in accordance with the seasonal variation of occurrence of *D. nationalis*. Thus, this species occurs more frequently at stations with relatively low mean integral temperatures, but it can also occur at higher temperature ranges.

(c) *Doliolum tritonis*.

This species was found in small numbers only on a few occasions in the oblique hauls and was seldom present in the surface hauls.

Occasionally the oozoids of *D. tritonis* were found unaccompanied by the gonozooids in the oblique hauls.

(i) Areas of distribution.

During the two years under observation this species was never found at inshore routine stations, but was taken periodically in small numbers at off-shore routine stations.

(ii) Seasonal occurrence.

Table 14 shows the approximate numbers of gonozooids and oozoids of *D. tritonis* caught during April, 1954, to February, 1956.

A total of 35 individuals was found at routine stations during the first year investigated. A few gonozooids were caught during autumn in the oblique net at station F where the temperature of the 0-50 metres layer was 16.23°C.

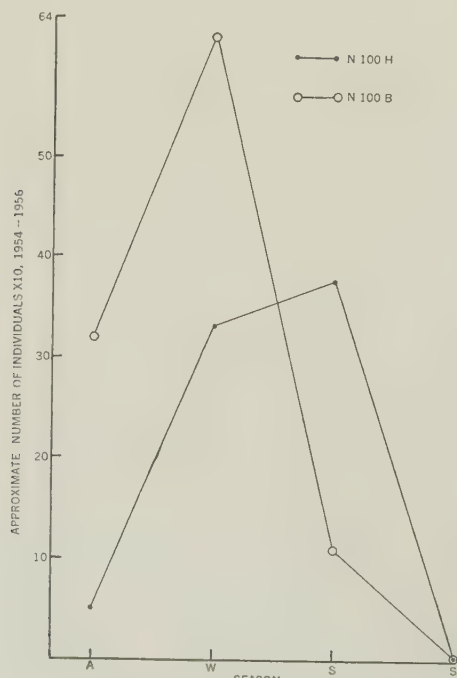


FIG. 5. SEASONAL VARIATION OF *DOLIOLUM NATIONALIS*, APRIL, 1954-FEBRUARY, 1956.

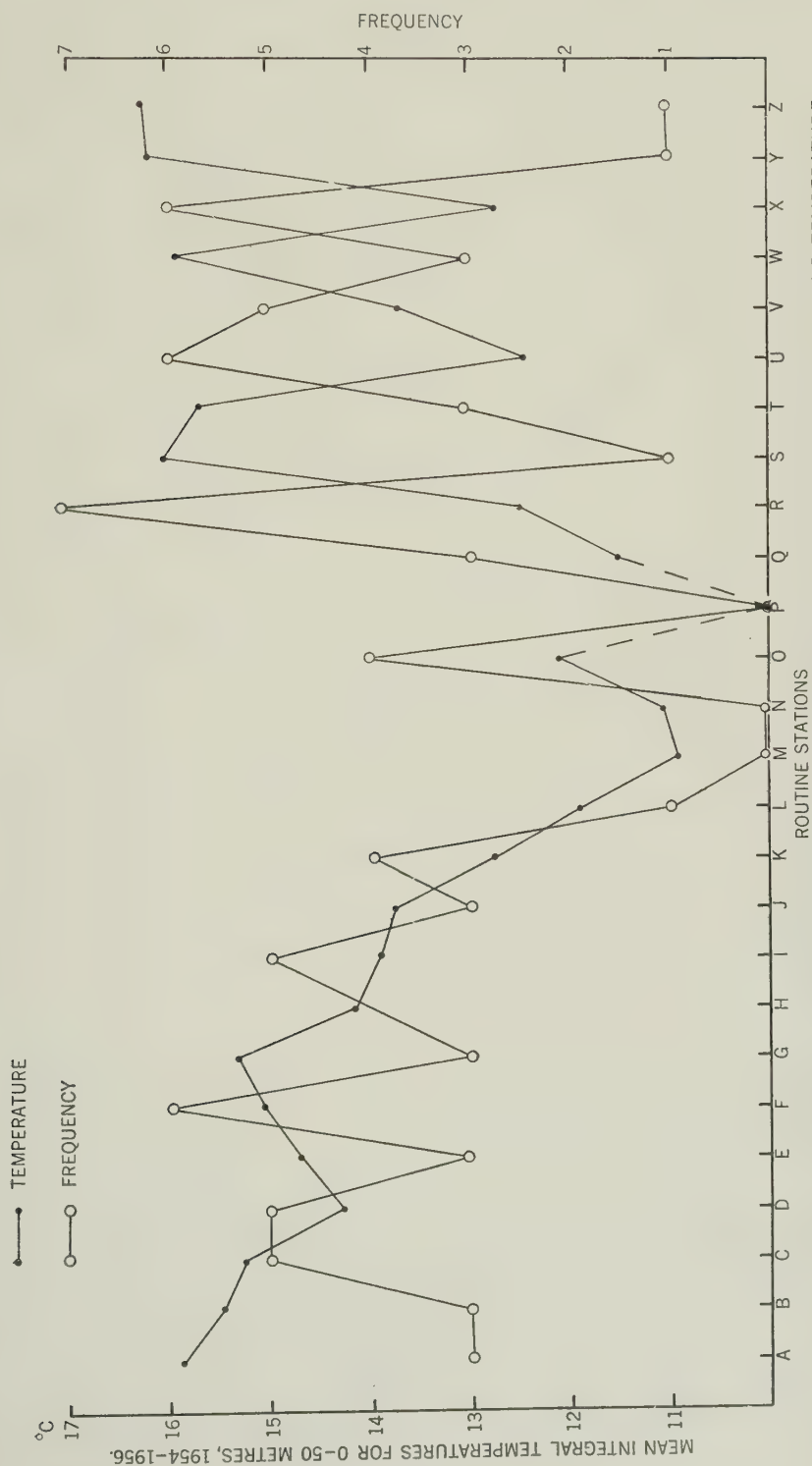


FIG. VI. INVERSE RELATIONSHIP BETWEEN THE FREQUENCY OF OCCURRENCE OF DOLIOLUM NATIONALIS AND TEMPERATURE, APRIL, 1954-FEBRUARY, 1956.

TABLE 14.

Season.	1954/55.				1955/56.			
	N100H.		N100B.		N100H.		N100B.	
	Gono-zoid.	Oozoid.	Gono-zoid.	Oozoid.	Gono-zoid.	Oozoid.	Gono-zoid.	Oozoid.
Autumn.....	—*	—*	3*	—*	—	—	—	3
Winter.....	—	—	—	—	—	—	—	3
Spring.....	—	—	—	10	—	3	—	25
Summer.....	10	—	6	6	—	3	6	60

* Data for two months only, viz. April and May.

In spring, 10 individuals were caught at stations A and I (average mean integral temperature of the 0-50 metres layer was 15.15°C).

During summer, 1954/55, 22 individuals were taken at stations A, B, G and T (average mean integral temperature of the 0-50 metres layer was 16.42°C).

In the year 1955/56 a few individuals were caught in oblique hauls during autumn and winter.

In spring, 1955, some 25 oozoids and 3 gonozoids were caught at stations A, B, F, H, I and Z in oblique and horizontal tow-nets. The average mean integral temperature of the 0-50 metres layer of water at these stations was 15.43°C.

In summer, 1955/56, a total of 60 oozoids and 6 gonozoids was taken at stations A, B, E, F, I, T, W, Y and Z in the oblique hauls only. The average mean integral temperature of the 0-50 metres layer at these stations was 16.58°C.

The seasonal variation of *D. tritonis* is shown in Figure 7. Concentrations of this species were low in autumn and winter, but numbers increased during spring to reach a maximum in summer in the oblique hauls. Catches made in the surface hauls remained at a low level during all seasons.

A close agreement exists between the mean integral temperatures of the 0-50 metres layer of sea-water and the frequency of occurrence of this species at the off-shore routine stations (see Fig. 8).

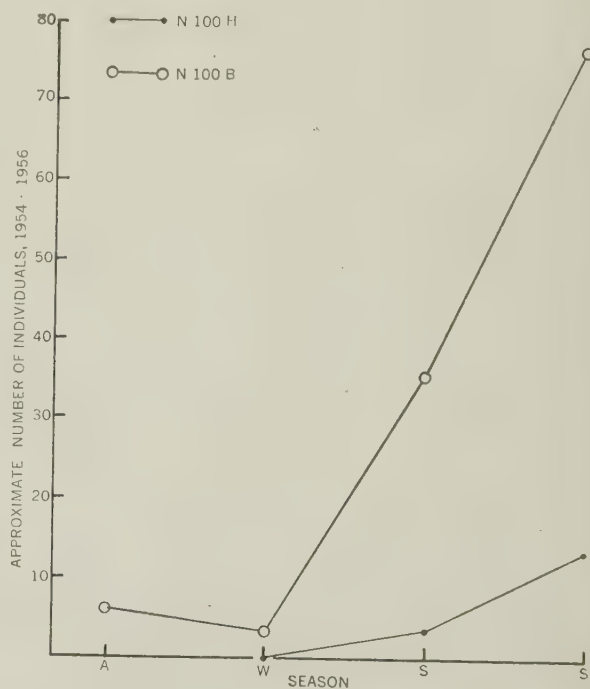


FIG. VII. SEASONAL VARIATION OF *DOLIOLUM TRITONIS*.
APRIL, 1954 - FEBRUARY, 1956.

The absence of *D. tritonis* at inshore stations K, L, M, N, O, P, Q, R, U and X, and its higher frequency of occurrence at off-shore routine stations, suggests that this species is mainly an oceanic form and it is likely to be distributed in waters which are warmer than those found close to the coast.

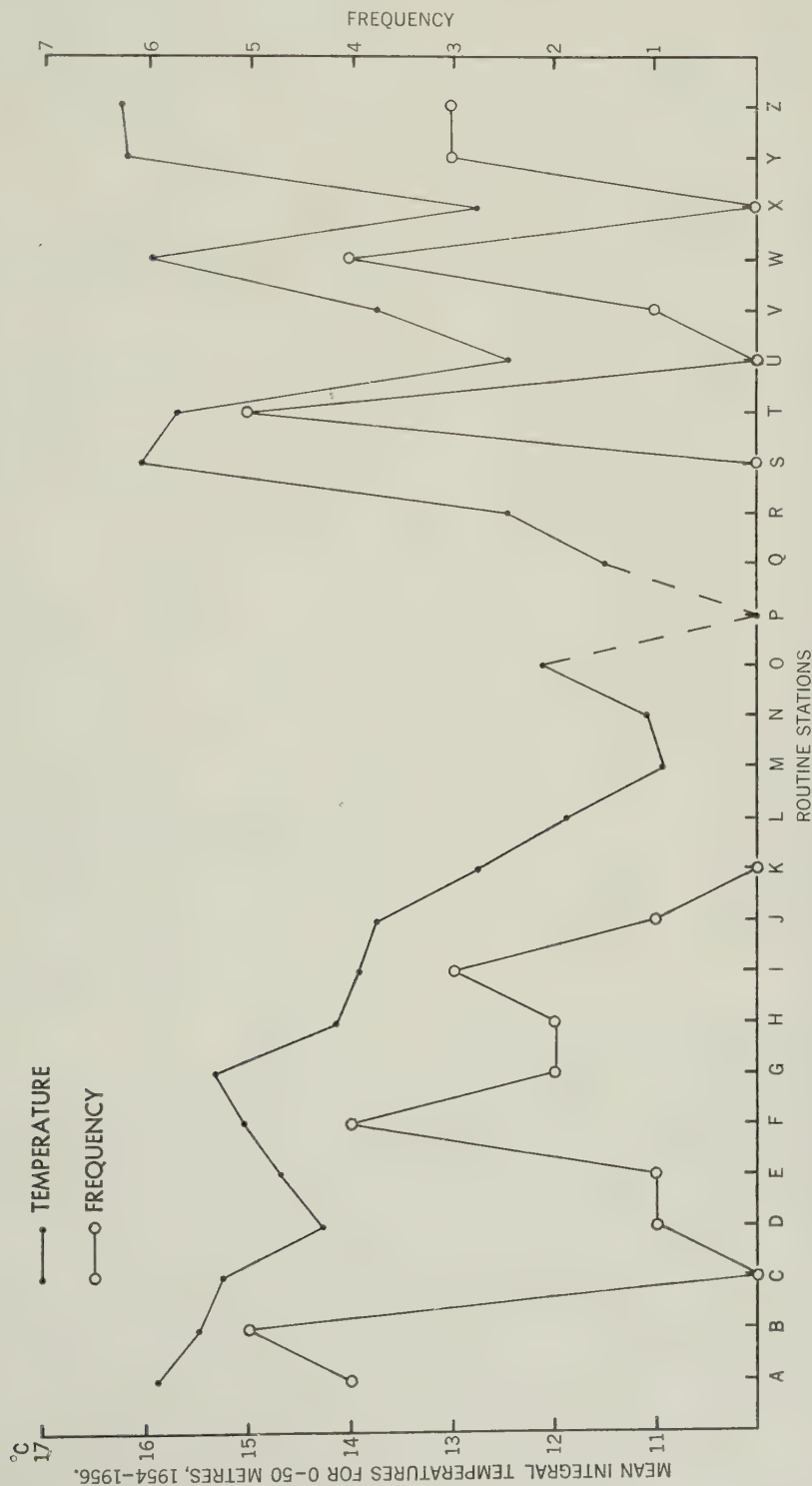


FIG. VIII RELATIONSHIP BETWEEN THE FREQUENCY OF OCCURRENCE OF DOLIOLUM TRITONIS AND TEMPERATURE, APRIL, 1954-FEBRUARY, 1956.

7. GENERAL DISCUSSION.

It has been pointed out (Russell, 1935) that in an area where water bodies mix, certain types of planktonic animals found can give a clue to the origin of the sea-water present. These animals should, from a practical point of view, be fairly large and easily identifiable; salps and, to a certain extent, doliolids, conform to this requirement.

It is of importance particularly in studying the migratory habits of pelagic fish to obtain information on the occurrence of these organisms.

The water in the routine area probably has two sources, viz. from the Benguela and Agulhas currents, which flow off the West and South-east coasts, respectively.

The composition of salp and doliolid populations off the West and South-east coasts of the Union differ. Organisms more tolerant of warm water would be expected to be found off the South-east coast whilst those which prefer cooler water might be expected off the West coast. Furthermore, it was found that in relatively cold water the number of species is more restricted but that the individuals occur in large numbers, whilst in warmer regions a greater variety of salps are found but not always in large quantities. However, *T. longicauda* occurred in large numbers in relatively warm water off both West and South-east coasts.

Species of salps found in sea-water at the higher mean integral temperature ranges were:—

T. longicauda, *T. democratica* (large individuals), *P. confoederata*, *C. pinnata* and *S. maxima*.

The occurrence of the above-mentioned salps, excluding *S. maxima*, in the routine area during December, 1955, to February, 1956, seems to indicate an incursion of warm water into the routine area during that period. It appears that under the influence of South-easterly winds, which are prevalent during summer and autumn, an influx of water from the Agulhas current took place during the later part of 1955 and early in 1956.

The occurrence of *T. longicauda* in large numbers on the West coast during May, 1955, at off-shore station A also suggests that a similar water movement took place during that year. No evidence of such water movements was found during the period April, 1954, to February, 1955.

T. democratica is commonly found in the routine area during spring and summer. In autumn and

winter smaller numbers of this species are found at off-shore routine stations. These individuals are generally smaller-sized than specimens obtained during spring and summer. The average lengths of aggregate and solitary individuals in autumn and winter are 0.9 cm. and 1.7 cm., respectively, and in spring and summer 1.4 cm. and 2.0 cm.

It has been observed that the nuclei of aggregate and solitary individuals have a purplish colour before preservation during spring, when unusually large numbers of *T. democratica* are present in the routine area.

It appears that the change in colour from white to purple of the nuclei of aggregate and solitary individuals, and the periodic increase in overall dimensions of both zooids of this species, can be associated with changing hydrological conditions. Spring, 1955, was very marked in this respect, when large numbers of *T. democratica* were present in the routine area.

Salinity values varied from about 33–35 per cent at the routine stations and appeared to play an unimportant role in the distribution of salps and doliolids.

The distribution of *D. tritonis* was limited exclusively to off-shore routine stations, and it was found in sea-water having a temperature range of 14.00°C to 18.99°C in the 0–50 metres layer. This condition, together with the rare occurrences of this species in surface tow-net hauls, appears to show that it is a stenothermal and oceanic form of plankton having a low tolerance for cold coastal waters. Both *D. tritonis* and *D. denticulatum* had their largest frequency of occurrence during summer, when largest catches of both species were made in oblique tow-net hauls.

D. nationalis was more frequently found during winter and in greater numbers in the oblique than in the surface hauls. The distribution of this species is also limited to off-shore stations and relatively low temperatures, although it has been found in association with *D. denticulatum* in temperate waters.

It is of interest to note that when any one species of salp occurs abundantly, most of the other plankton genera are absent from the catches. In smaller numbers they may be accompanied by other plankton genera.

Salps and doliolids do not normally constitute part of the diet of pilchards and maasbankers. In November, 1956, a pilchard sample was received

from a station situated on the South-east coast. The stomach contents of these fish contained large quantities of *T. longicauda*, in a readily identifiable condition, but this ingestion seemed to be accidental in view of the filter feeding habits of these fish.

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TABLE 15.—Average Integral Temperatures for the 0-50 metres layer, April, 1954-February, 1955. °C.

Station.	1954.						1955.		Average.			
	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.		Dec.	Jan.	Feb.
A.....	18.92	17.62	15.83	15.03	14.45	14.86	16.17	17.17	17.33	13.96	14.91	16.02
B.....	16.63	17.51	15.03	14.77	14.94	14.65	15.67	15.71	16.01	14.33	15.10	15.49
C.....	14.93	14.34	15.43	14.87	14.25	15.10	15.80	16.90	15.95	14.83	14.60	15.18
D.....	14.80	14.61	14.12	14.44	13.96	14.89	15.09	14.86	13.97	13.55	14.44	14.43
E.....	13.65	15.55	14.85	14.46	13.77	14.67	15.37	13.51	14.71	14.18	14.64	14.40
F.....	16.23	13.57	16.25	14.60	14.22	14.75	15.27	16.71	17.24	14.71	13.09	15.15
G.....	17.04	16.62	16.04	14.94	14.42	14.93	15.54	14.44	16.99	14.26	14.84	15.46
H.....	12.93	14.47	15.37	14.77	14.16	14.94	15.23	13.88	16.50	12.05	11.85	14.20
I.....	13.64	14.94	15.26	14.39	14.04	14.81	14.13	14.65	15.51	12.94	12.45	14.25
J.....	13.82	15.59	14.95	14.91	14.23	14.49	12.68	12.15	13.54	13.16	12.96	13.86
K.....	11.53	13.23	12.98	14.03	13.97	12.80	12.65	12.97	12.19	12.68	12.19	12.84
L.....	11.32	11.30	13.18	13.24	13.45	12.22	12.07	10.74	11.22	12.54	11.39	12.06
M.....	12.53	14.07	11.46	11.67	13.11	10.49	9.67	9.79	9.76	10.37	11.19	11.28
N.....	11.10	14.05	13.35	12.69	12.38	11.27	10.14	10.15	10.67	11.12	10.77	11.61
O.....	12.17	12.50	13.65	14.44	12.97	12.49	12.65	10.15	11.17	12.15	10.79	12.28
Q.....	10.29	14.06	12.33	14.23	13.49	11.62	11.53	9.59	10.89	10.81	10.63	11.77
R.....	11.60	14.31	14.16	14.89	13.72	13.41	13.58	12.00	12.82	10.73	10.74	12.91
S.....	18.91	17.47	16.66	15.03	14.53	14.77	16.08	15.67	17.40	14.41	16.00	16.09
T.....	19.01	15.55	15.98	15.13	14.56	14.76	16.16	14.57	17.06	16.33	17.37	16.04
U.....	10.48	14.92	13.43	14.00	13.16	13.30	13.17	11.94	13.76	10.41	10.38	12.63
V.....	11.57	14.83	14.65	14.27	14.03	14.60	15.82	13.37	13.93	12.59	11.41	13.73
W.....	18.47	15.97	16.01	15.16	14.40	15.07	16.49	14.95	16.01	17.59	17.05	16.11
X.....	11.12	14.36	14.27	13.93	13.59	14.65	13.47	11.92	13.64	10.83	10.87	12.97
Y.....	—	—	—	—	—	—	—	—	—	—	—	—
Z.....	—	—	—	—	—	—	—	—	—	—	—	—
Average.....	14.03	14.85	14.58	14.34	13.90	13.89	14.11	13.38	14.27	13.07	12.94	13.94

TABLE 16.—Average Integral Temperatures for the 0–50 metres layer, March, 1955–February, 1956. °C.

Station.	1955.										1956.		Average.
	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
A.....	14.44	17.38	15.07	15.54	14.68	15.16	15.13	15.16	15.96	16.70	17.55	16.16	15.74
B.....	15.63	14.84	15.07	15.01	14.57	14.85	15.23	14.69	15.97	16.73	17.48	15.78	15.49
C.....	14.31	16.42	15.18	14.71	14.59	14.43	14.95	14.80	15.38	15.49	17.08	15.67	15.25
D.....	13.71	15.88	13.42	13.51	13.93	14.44	14.47	14.35	14.58	12.99	14.59	13.69	14.13
E.....	14.15	14.64	13.96	13.19	14.58	14.49	14.98	15.11	14.05	15.27	17.42	16.00	14.82
F.....	14.02	16.37	14.40	13.46	13.46	14.15	14.95	14.93	15.59	15.33	17.16	15.13	14.91
G.....	14.24	16.70	14.73	14.35	14.77	14.32	14.82	15.23	15.97	15.73	17.76	13.33	15.16
H.....	13.61	16.21	11.86	13.93	14.03	13.95	14.52	15.33	14.84	13.49	13.77	13.74	14.11
I.....	12.87	11.90	13.45	12.04	13.26	14.23	14.70	13.06	14.53	14.17	14.44	14.41	13.59
J.....	13.86	12.55	13.55	12.57	14.10	13.97	14.77	13.40	12.08	14.63	14.18	14.06	13.64
K.....	12.77	12.43	12.78	12.24	13.29	13.16	14.55	13.87	10.17	11.43	12.97	12.44	12.68
L.....	11.57	11.12	11.47	12.04	10.96	12.72	12.22	13.05	10.97	10.15	12.05	11.76	11.67
M.....	9.90	11.79	10.95	10.81	11.44	12.06	10.97	9.74	9.09	8.91	11.31	10.40	10.61
N.....	10.02	10.55	10.70	10.62	11.29	11.99	10.91	10.70	10.08	9.54	9.96	10.79	10.60
O.....	11.92	12.21	11.41	11.16	10.86	12.63	13.56	13.63	11.25	10.93	11.76	12.13	11.95
Q.....	10.81	11.64	10.60	10.95	11.39	12.50	13.17	12.05	9.63	9.79	11.17	11.38	11.26
R.....	11.09	11.35	11.34	10.50	14.08	13.09	13.61	14.30	10.66	11.69	11.19	11.71	12.05
S.....	15.59	—	—	—	—	—	—	—	—	—	—	—	—
T.....	14.13	16.80	14.86	15.23	14.67	14.16	14.97	15.30	16.23	16.87	17.41	14.00	15.39
U.....	11.18	10.71	11.64	12.33	13.03	13.89	13.83	13.59	10.89	13.28	11.51	11.26	12.26
V.....	12.65	12.27	12.23	12.78	14.29	14.00	14.48	14.93	13.61	16.32	13.43	13.81	13.73
W.....	14.13	17.00	15.13	14.55	14.81	14.41	14.93	15.29	16.60	17.02	18.99	16.12	15.75
X.....	11.85	12.65	12.09	11.13	13.38	13.52	14.09	13.49	12.50	12.27	10.86	12.32	12.51
Y.....	—	17.98	15.35	15.71	14.69	15.30	15.16	15.24	16.04	16.73	18.05	17.80	16.19
Z.....	—	17.15	15.78	15.53	14.63	15.13	15.27	15.14	15.72	16.81	18.44	18.95	16.24
Average.....	12.98	14.11	13.21	13.53	13.53	13.86	14.18	14.02	13.43	13.84	14.61	13.87	13.76



PLATE I.

DENSITY DISTRIBUTION OF *Thalia democratica*, APRIL, 1954–FEBRUARY, 1955.



PLATE 2.

DENSITY DISTRIBUTION OF *Thalia democratica*, MARCH, 1955–FEBRUARY, 1956.



PLATE 3.

DISTRIBUTION OF LESS COMMON SPECIES OF SALPS, APRIL, 1954-FEBRUARY, 1956.

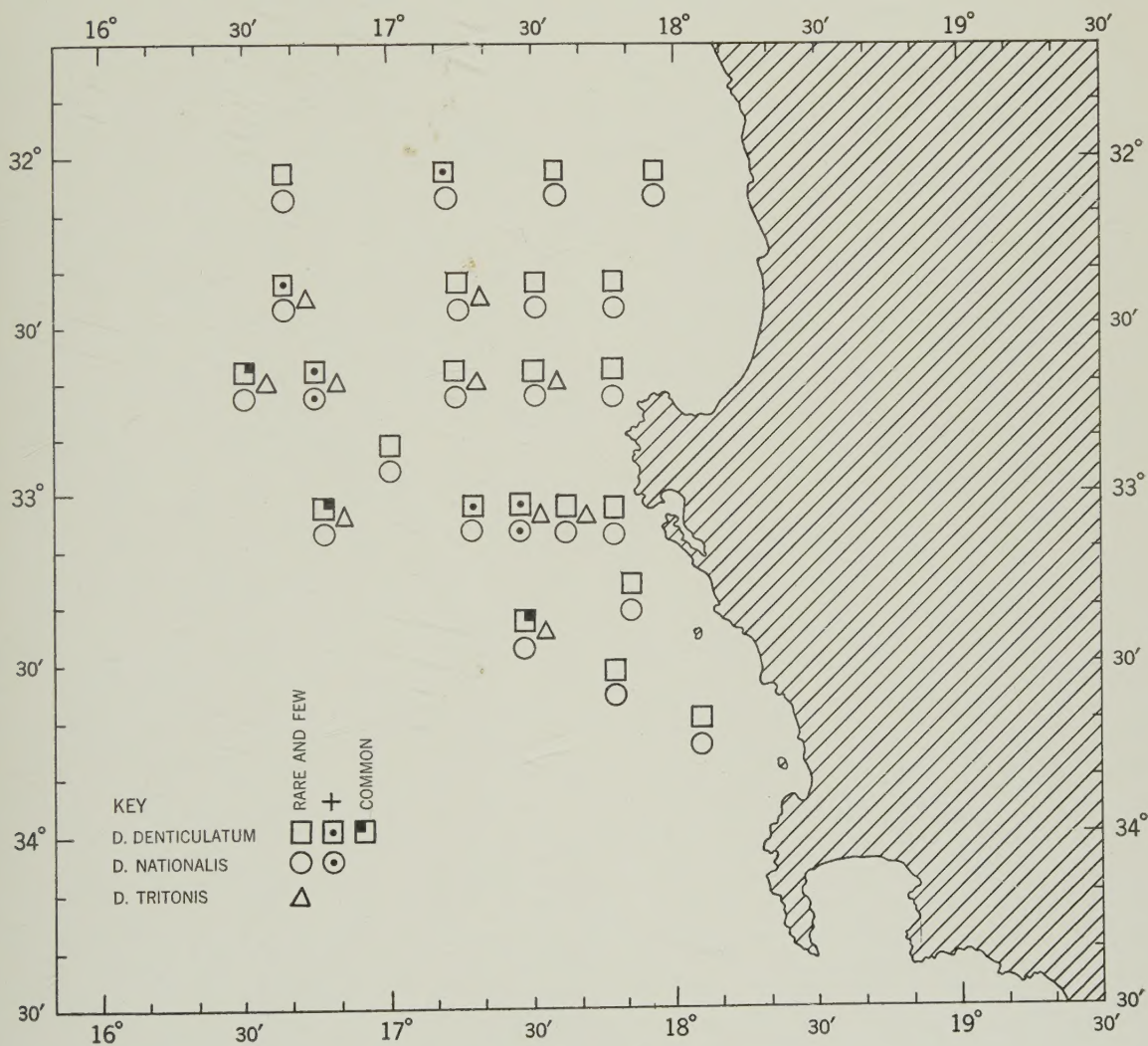


PLATE 4

DENSITY DISTRIBUTION OF DOLIOLIDS, APRIL 1954–FEBRUARY, 1956.

